Technical Report CHL-99-9

Coastal and Hydraulics Laboratory

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Ashtabula River, Ohio, Sedimentation Study Report 1, Field and Numerical Model Investigations of Channel Scour; 1994 Interim Results

Ronald E. Heath, Timothy L. Fagerburg, Trimbak Parchure, Allen M. Teeter, and Bill Boyt

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Preface

This report describes preliminary results of field and numerical model investigations of sediment transport in the Ashtabula River, northeast Ohio. The study was conducted by personnel of the U.S. Army Engineer Research and Development Center (ERDC), Waterways Experiment Station (WES), Vicksburg, MS, in cooperation with the U.S. Army Engineer District, Buffalo, for the U.S. Environmental Protection Agency (USEPA). Project manager for the Buffalo District was Mr. Stephen Golyski. Project manager for the USEPA, Region 5, was Mr. Edward J. Hanlon.

The initial scope of work for this investigation was prepared by Drs. Mark S. Dortch and Carlos Ruiz of the ERDC Environmental Laboratory; Messrs. Ronald E. Heath, Math Modeling Branch, Waterways Division, Hydraulics Laboratory (HL), ERDC; Allen M. Teeter, and Timothy L. Fagerburg, Estuarine Processes Branch, Estuaries Division (ED), HL; Mr. Bradley M. Comes of the ERDC Information Technology Laboratory; and Mr. James L. Wuebben of the U.S. Army Cold Regions Research and Engineering Laboratory with subsequent revisions by Dr. Ruiz and Messrs. Heath, Teeter, and Fagerburg during the period March 1992 to January 1994.

The field and numerical model investigations described herein were conducted between March 1994 and August 1994 by HL personnel. Project coordinator for HL was Mr. Heath. The field investigation was conducted by Messrs. Fagerburg, Howard A. Benson, Thad C. Pratt, Samuel E. Varnell, and Joseph W. Parman, all of the Estuarine Processes Branch; and Byron M. Reed, an HL contract student. Mr. Richard Griffith, Buffalo District, also assisted in the field investigation. The numerical model investigation was conducted by Messrs. Heath, Bill Boyt, and Joseph V. Letter, Estuarine Processes Branch, with technical support from Mr. John T. Cartwright, Estuarine Simulation Branch, ED.

This report was written by Messrs. Heath, Fagerburg, Teeter, Boyt, and Dr. Trimbak Parchure, ED. The study was conducted under the general supervision of Messrs. Frank A. Herrmann, Jr., Director, HL; Richard A. Sager, Assistant Director, HL; William H. McAnally, Chief, ED; Dr. Larry L. Daggett, Acting Chief, Waterways Division; Mr. George M. Fisackerly, Chief, Estuarine Processes Branch; and Mr. Michael J. Trawle, Chief, Math Modeling Branch.

In addition to this study, three subsequent studies were conducted by WES: A Field Data Collection Study (Report 2); A Sedimentation Study (Report 3); and A Numerical Model Study (Report 4). This report is 1 of the series.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL James S. Weller, EN, was Commander.

This report should be cited as follows:

> Heath, Ronald E., Fagerburg, Timothy L., Parchure, Trimbak, Teeter, Allen M., and Boyt, Bill. (2000). "Ashtabula River, Ohio, Sedimentation Study; Report 1, Interim Results of Field and Numerical Model Investigations of Channel Scour," Technical Report CHL-99-9, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

1 Introduction

Background

The Ashtabula River flows north into Lake Erie at the city of Ashtabula in northeast Ohio. The Federal navigation project in the lower Ashtabula River contains a breakwater-protected harbor in Lake Erie and a navigable waterway extending about 3.2 km (2 miles) upstream to the 24th Street Bridge (Figure 1). Sediments in the harbor and lower 600 m (2,000 ft) of the river are classified as suitable for open lake disposal whereas sediments upstream of the lower 600 m (2,000 ft) of the waterway to the 24th Street Bridge are classified as unsuitable for open lake disposal. In the harbor and lower 600 m (2,000 ft) of the river, dredging operations are conducted as required to permit commercial navigation. Dredging operations in the remainder of the waterway were suspended in the 1970s, closing the channel to commercial navigation in response to the increased cost of safe removal and disposal of sediments contaminated with heavy metals, chlorinated hydrocarbons (including, in some locations, toxic levels of polychlorinated byphenyls (PCBs)), and polynuclear aromatic hydrocarbons. The waterway is heavily used for recreational navigation. Limited dredging operations were conducted in the reach upstream of the 5th Street Bridge in 1993 to maintain safe navigation conditions in this reach.

Objectives

The overall objective of this study is to determine the potential magnitude and extent of scour that may occur during a flood event or in response to rapid changes in Lake Erie stages. This scour has the potential to cause exposure and dispersal of contaminants buried in the channel bed sediments. This objective is to be accomplished by a combination of field data collection and analysis and numerical model studies as described in the model workplan/ proposal.[1] In addition to the study of potential scour for existing conditions, the numerical model

[1] Memorandum for Record, CEWES-HR-M, 22 February 1994, Subject: "Time and cost estimate for data collection and analysis and numerical model studies of sediment transport in the Ashtabula River System."

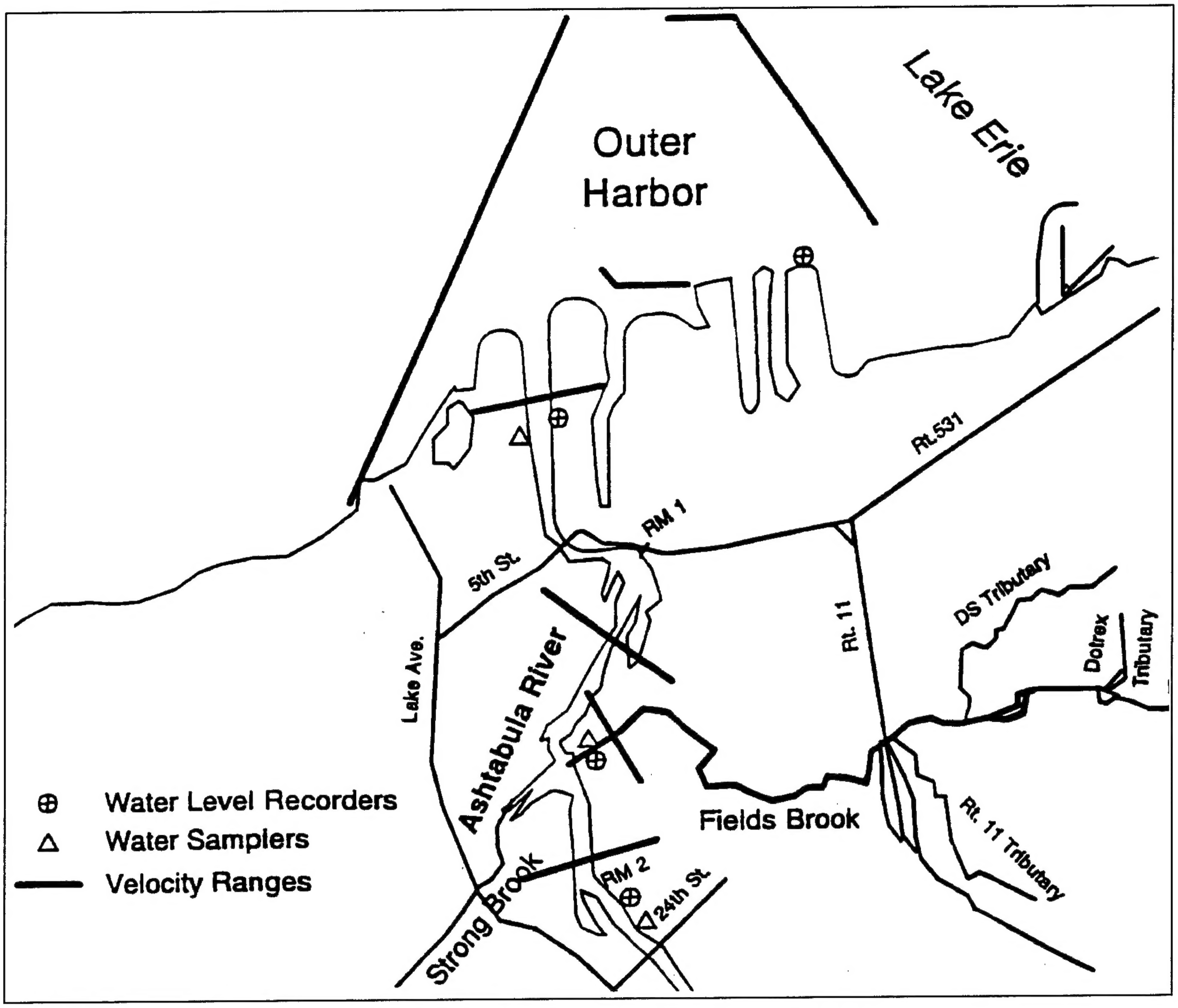

Figure 1. Project location and field data monitoring locations

will be used to evaluate the impact of various dredging alternatives. Authorization to proceed with this study was received on 7 March 1994.[1]

The immediate objectives, as defined in the authorization to proceed,[1] are (a) to determine whether the channel scour is highly probable, warranting a detailed study of sediment transport, or whether the erosion is so improbable as to eliminate or reduce the requirement of a thorough investigation and (b) to identify modifications to the scope of work that should be considered to better achieve the overall objective. To achieve the immediate objectives, a simplified numerical model has been developed to estimate scour potential using

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[1] Letter from Mr. Edward J. Hanlon, U.S. Environmental Protection Agency, Region 5, to Mr. Steven Golyski, U.S. Army Engineer District, Buffalo , 7 March 1994, regarding "Fields Brook Superfund Site, Ashtabula, Ohio.

preliminary and incomplete data from the field data collection and analysis effort. The results of this preliminary investigation are described herein.

Field data collection is scheduled to continue through the end of 1994 and may be extended if deemed reasonable and necessary to achieve the study objectives. As additional data become available, the numerical model will be updated as appropriate to improve the precision and accuracy of the study results. Final reports documenting the field data collection and analysis and numerical model investigations will be prepared at the conclusion of the study.

Related Studies

The U.S. Army Cold Regions Research and Engineering Laboratory conducted an investigation of the ice regime of the Ashtabula River.[1] The purpose of that study was to determine if ice processes have a significant impact on channel scour. The results to date indicate that the ice processes are less significant than large open-water flood events, such as the 100-year return period flood event evaluated in this study.

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[1] James L. Wuebben and John J. Gagnon. "Ice regime of the Ashtabula River, Ashtabula, Ohio," (1995), U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH.

2 Field Data Collection and Analysis

Field data collection and analysis procedures are described in Appendix A, "Scope of Work for Hydrodynamic and Sediment Transport Field Data Collection and Analysis," Appendix B, "QA/QC Plan for Field Data Collection," and Appendix C, "Health and Safety Plan," of the model workplan/ proposal.[1]

Data Collection Activities

Personnel of the U.S. Army Engineer Research and Development Center (ERDC), Waterways Experiment Station (WES), Vicksburg, MS, conducted a reconnaissance trip to Ashtabula, OH, to identify locations of equipment installation and make measurements for design of the equipment mounting brackets. At this time contact was made with individual property owners for permission to access the property and to allow for installation of equipment. All parties requested a letter citing a hold-harmless liability statement. Letters were drafted and sent to all parties on 19 May 1994.

The water level recorder equipment was received at WES on 29 April 1994, and the automatic water samplers were received on 9 May 1994.

In preparation for the field effort, fabrication of mounting brackets for long-term monitoring equipment was begun in April and completed in early May. The boats and motors to be used for the study were serviced and readied for the field data collection effort. Water sample bottles and sediment sample containers for use in the study were ordered and received. A rental truck was contracted for shipment of equipment to Ashtabula.

Field data collection efforts were initiated on 4 June 1994, in accordance with the WES model workplan/proposal[1] with the installation of long-term monitoring

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[1] Memorandum for Record, CEWES-HR-M, 22 February 1994, Subject: "Time and Cost Estimate for Data Collection and Analysis and Numerical Model Studies of Sediment Transport in the Ashtabula River System."

equipment. The locations of these monitoring systems are shown in Figure 1. The water level recorders maintain a 15-min sample interval for data recording. The water samplers are outfitted with a float switch that initiates the sampling routine when the water level rises to a preset elevation.

Bottom sediment samples were obtained at 12 locations as indicated in Figure 2. Two types of sampling devices were used to collect the bottom material samples. A WILDCO 6-in. box core sampler was used to collect undisturbed samples that would eventually be used in the erosion and shear stress testing. The other sampler was a push core sampler that collects up to an 0.5-m- (18-in.-) deep sample for use in material classification and grain size analysis. The samples were kept cool and shipped back to WES for refrigerated storage until laboratory analysis could be performed.

From 6 June through 9 June 1994, river current measurements were performed. The locations of the data collection ranges are shown in Figure 1. Velocity profiles at the four data collection ranges were obtained consistently over a 12-hr period each day. Acoustic Doppler Current Profile (ADCP) equipment was used to obtain the velocity data. The velocity data collected over this period were brought to WES for further processing and analysis. The memory cartridges from the water level recorders were retrieved for processing and replaced with new ones. No water samples were collected by the automatic water samplers during the velocity data collection period because water levels remained below the preset activation level.

At the time of this report, monthly service trips were being performed by personnel from WES and U.S. Army Engineer District, Buffalo. Onsite training was being conducted on methods and techniques for maintenance and service of the long-term equipment. Service trips were performed in July and August 1994. All the equipment was operating correctly. Water level recorders were collecting data at 15-min sample intervals. Water samplers collected samples for certain events during the installation period. Figures 3-6 are examples of the time-history of water level fluctuations for the period 6 July through 9 August 1994. The water sample notations shown in Figures 5 and 6 represent times at which the water sampler was activated. It should be noted here that from the recorded time and date at which the sampler was activated, no extended rise in the water level was observed.

Analysis

At the time of this report, data analysis of the velocity profiles obtained from the ADCP was ongoing. Preliminary results indicate that the velocity range was 0-30 cm/sec (0-1.0 ft/sec). No significant storms or hydrologic events occurred during the data collection period.

Laboratory analysis of the suspended sediment and bottom material samples was also ongoing. Soil testing and particle sizing were a few of the analyses remaining to be performed.

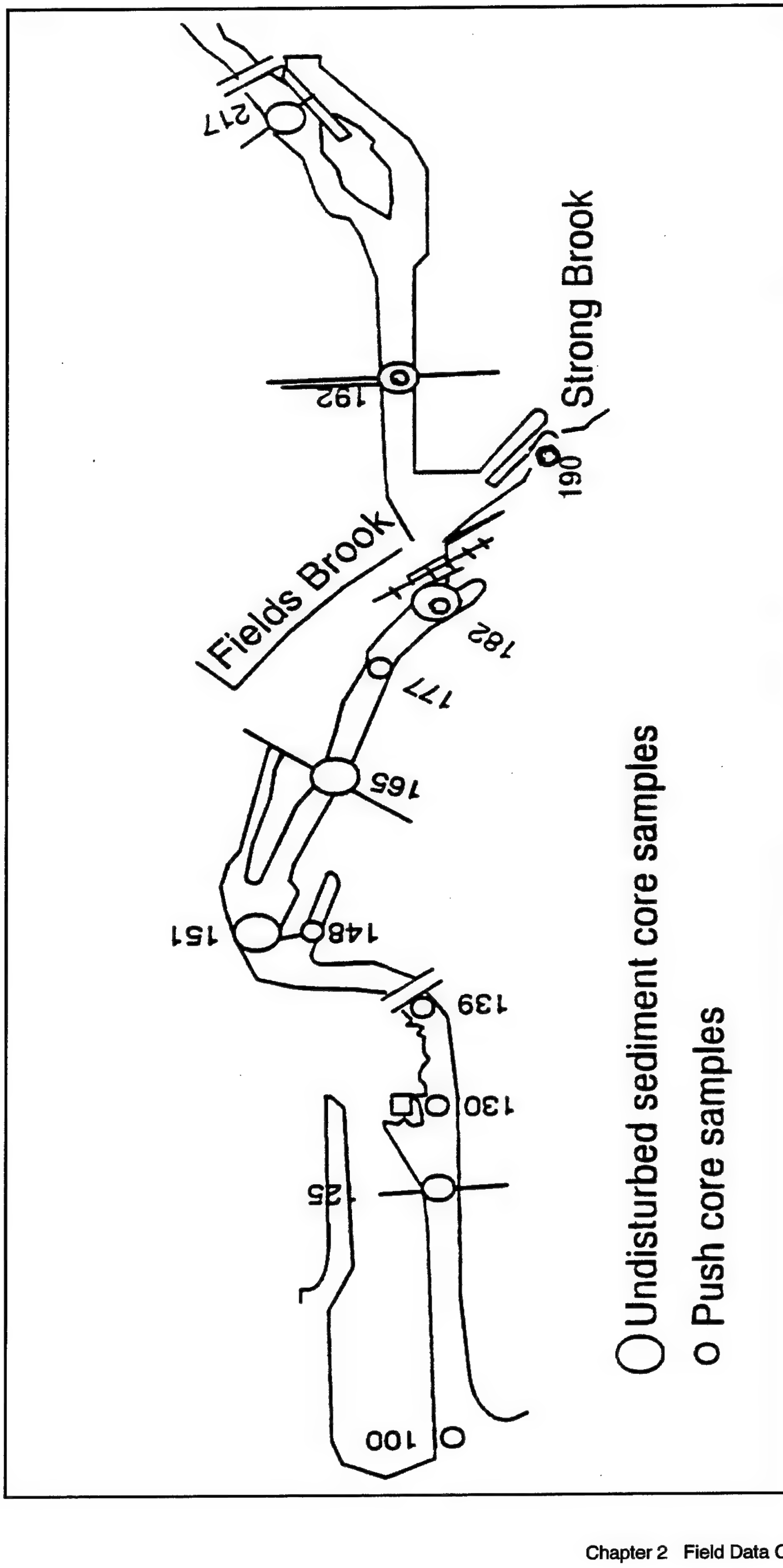

Figure 2. Bottom sediment sampling locations

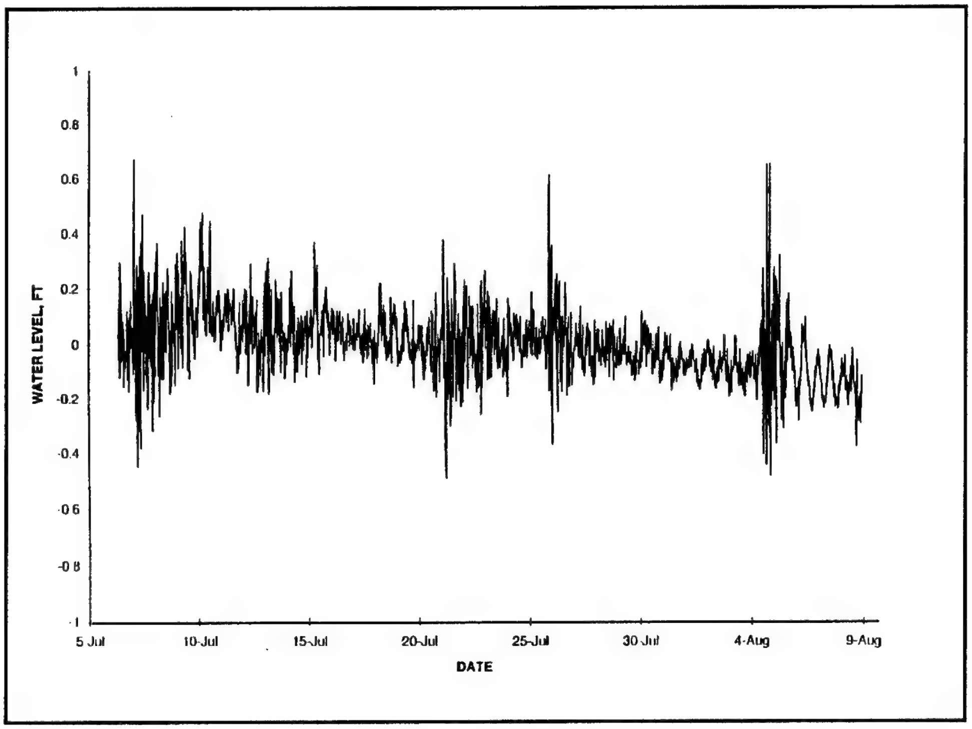

Figure 3. Time-history of water level fluctuations at the outer harbor monitoring location (to convert water level to meters, multiply feet by 0.3048)

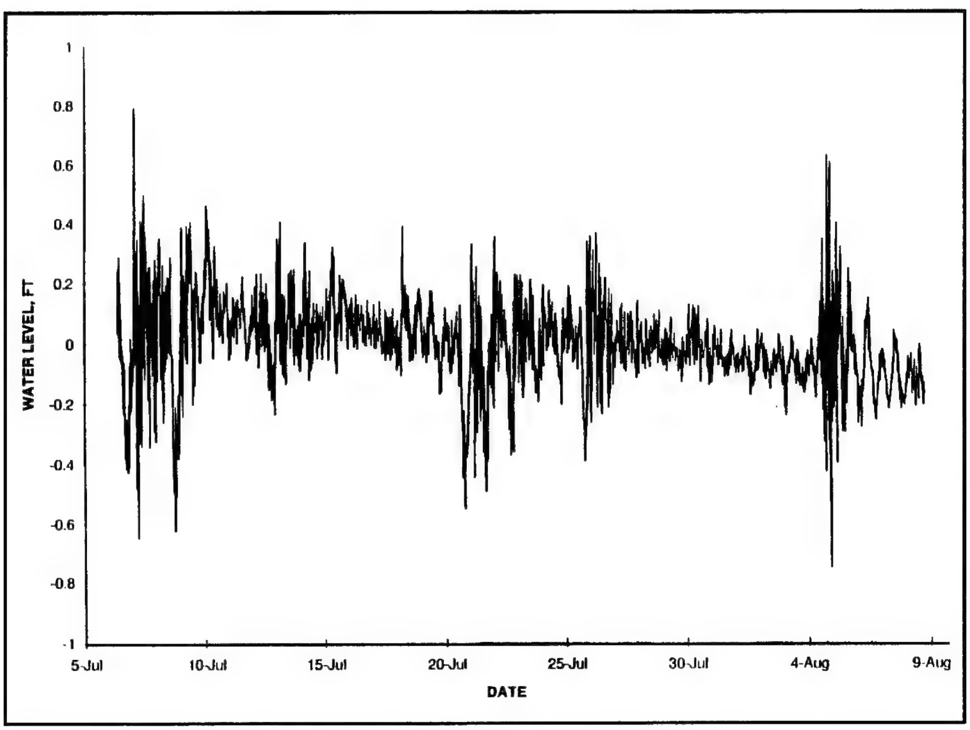

Figure 4. Time-history of water level fluctuations near the mouth of the river (to convert water level to meters, multiply feet by 0.3048)

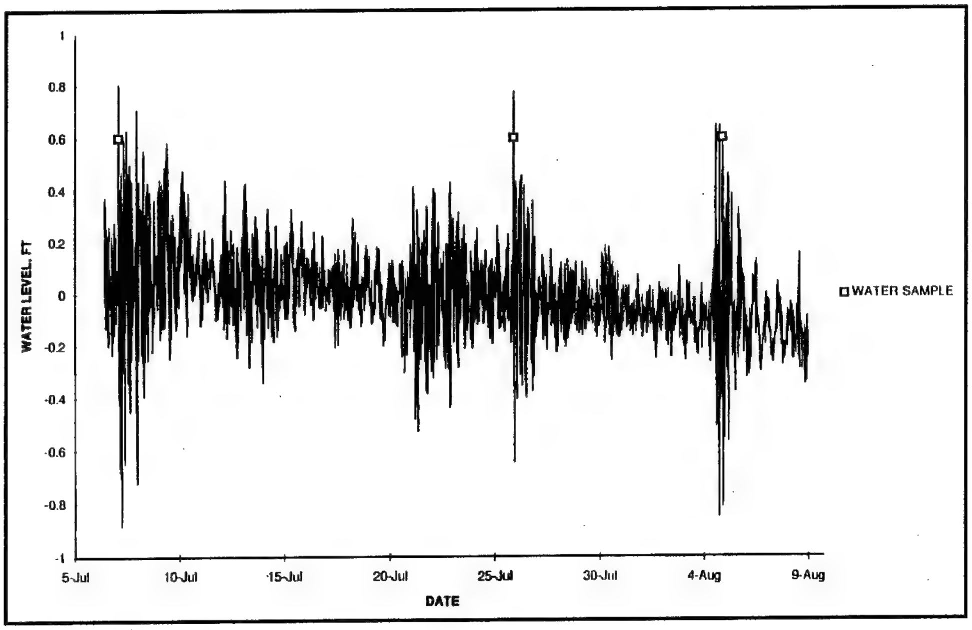

Figure 5. Time-history of water level fluctuations and water sampling events at the Fields Brook monitoring location (to convert water level to meters, multiply feet by 0.3048)

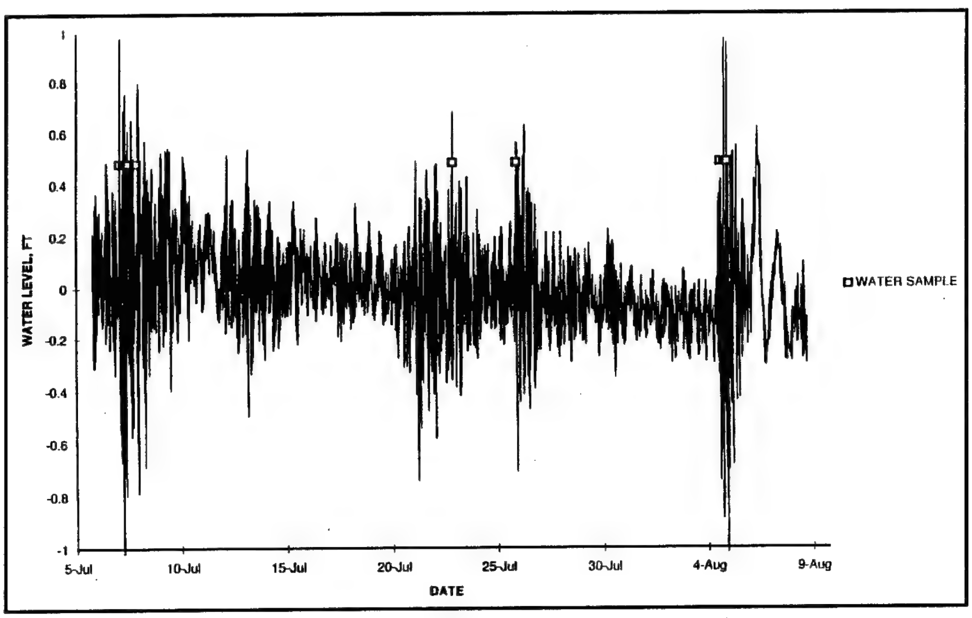

Figure 6. Time-history of water level fluctuations and water sampling events near the 24th Street monitoring location (to convert water level to meters, multiply feet by 0.3048)

The results of laboratory erosion tests showed that the critical shear stress for commencement of surface erosion was as low as 0.2 to 0.3 Pa[1] (0.004 to 0.006 lbf/ft^2). Continued erosion over a 30-min duration was observed at higher shear stresses on the order of 0.5 to 0.6 Pa (0.010 to 0.013 lbf/ft^2). If the applied bed shear stress during the flood event is greater than the critical shear stress for erosion, then the bed material will be eroded. Based on this information, if the high-flood duration extends over a long period of time, there is a very high probability that the relatively clean surface layer of bed sediments covering the contaminated sediments may be completely eroded, thus exposing and eroding the contaminated sediment.

It is necessary to note here that sediment beds are often classified under two main groups: deposited beds and compacted beds. The uppermost sediment layer is the deposited bed, which goes through cyclic processes of erosion and deposition in a dynamic environment consisting of tides or flood discharges. This layer is formed by freshly deposited sediments with residence time extending from a few hours to a few months. Underneath this surface layer lies a compacted bed, which has not been disturbed by erosional processes over a long period of time, and has undergone self-weight consolidation. Even if this layer has a sediment with the same clay minerals and particle size distribution as the upper layer, it has low water content and high bulk density. Shear strength of such compacted beds could be several times higher than that of the deposited beds. For a given flow condition, the upper layer may erode, but the lower layer may not erode. It is therefore necessary to ascertain the shear strength of beds over a vertical by testing samples collected by way of bore holes.

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[1] The pascal (Pa) is an SI unit of stress or pressure defined as a force of one newton applied over an area of one square meter (N/m^2). One pound per square foot (lbf/ft^2) is approximately equal to 47.9 Pa.

3 Model Development and Testing

Approach

The preliminary model study was conducted using the TABS-MD modeling system, a family of numerical models that provide multidimensional solutions to open-channel flow and sediment transport problems.[1] The TABS-MD modeling system is the U.S. Army Corps of Engineers standard for general-purpose modeling of two-dimensional, depth-averaged, open-channel flow and sediment transport problems and has been supported by WES since the mid-1980s. RMA-2V, a two-dimensional, depth-averaged hydrodynamic numerical model, was used to generate water levels and current patterns. RMA-2V employs finite element techniques to solve the Reynolds form of the Navier-Stokes equations for turbulent flows. Input data requirements for RMA-2V include a finite element mesh describing system geometry, Manning's roughness coefficients, turbulent exchange coefficients, and boundary conditions.

Model Development

A preliminary TABS-MD finite element mesh (Figure 7) consisting of 918 elements and 2,942 nodes was developed from National Oceanic and Atmospheric Administration (NOAA) Survey Chart 14836, Ashtabula Harbor, dated 24 November 1979. Typical mesh element size in the Ashtabula River was 120 m (400 ft) longitudinally and 18 m (60 ft) laterally. Two sets of mesh bathymetry were developed by updating the initial mesh with hydrographic survey data collected before and after the interim dredging conducted in 1993. Bathymetry was referenced to the low water datum, 173.3 m (568.6 ft) International Great Lakes Datum (IGLD) 1955. Subsequent finite element meshes will incorporate additional nodes and elements to more precisely resolve variations in both the mesh bathymetry and the computed bed shear stress.

[1] William A. Thomas and William H. McAnally, Jr. (1985). "User's manual for the generalized computer program system: Open-channel flow and sedimentation, TABS-2," Instruction Report HL-85-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

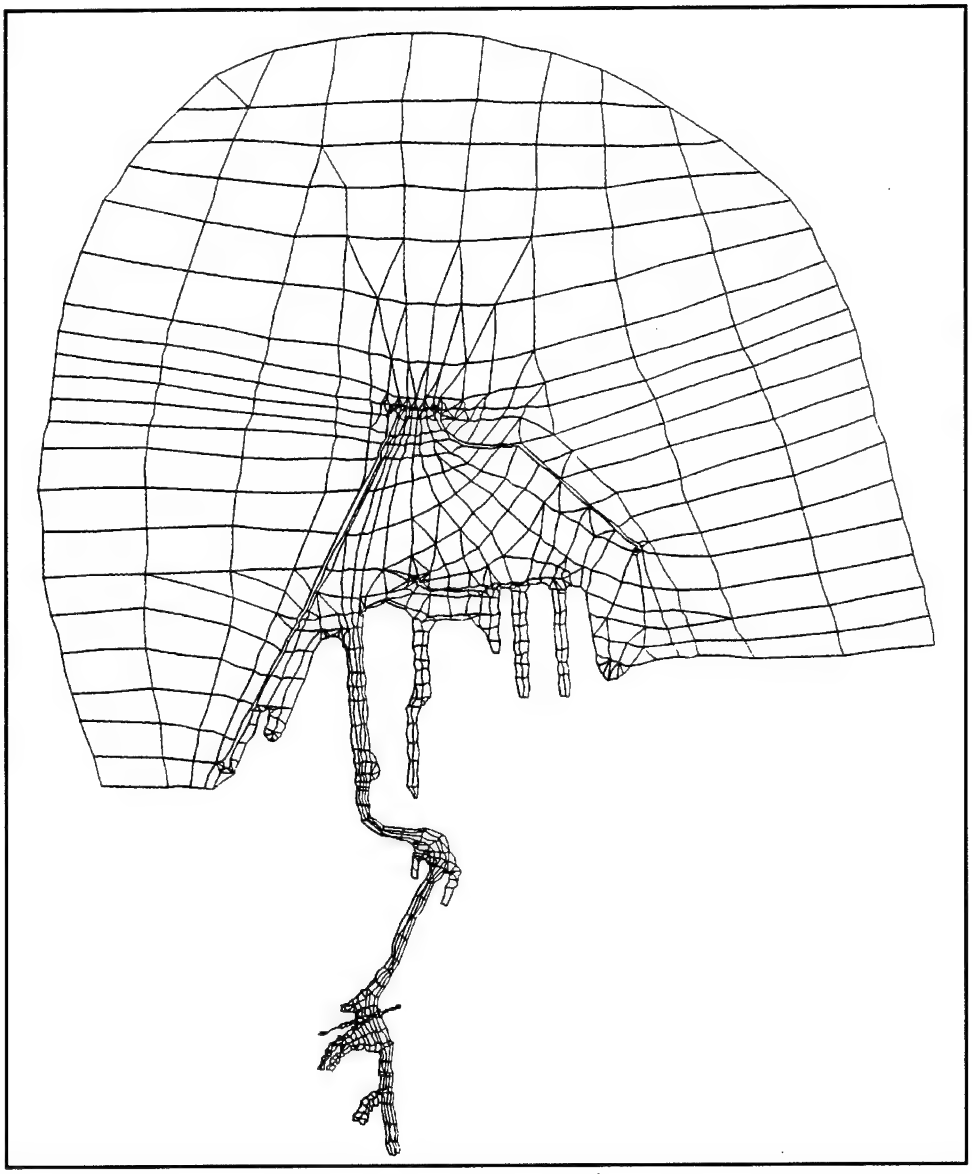

Figure 7. Finite element mesh for preliminary numerical model

Initially, a single base value of the roughness coefficient, Manning's n value, was used for the entire grid and its variation with water depth was calculated.[1] Assumption of a base Manning's n value of 0.04 for the channel produced the depth variation shown in the following tabulation:

Depth, m ft	Manning's n
1.8 (6)	0.039
3 (10)	0.029
18 (60)	0.020

[1] Gary Livingston Brown. (1995). "The preliminary design of stormwater management systems, with advances in open channel design," M.S. thesis, University of Florida, Gainesville.

These values fall within the generally accepted range for dredged channels and natural streams.[1] Subsequent models will incorporate spatial variations of roughness coefficients to account for changes in bed and form roughness. The sensitivity of model results to the roughness coefficient and Peclet number will be evaluated. If sufficient field data are collected, coefficient values will be checked by comparison of observed and computed data.

Two types of boundary conditions were required to perform each simulation using this model. At the downstream boundary in Lake Erie, the stage relative to the low-water datum was specified. Inflows were specified at the upstream model boundaries of the Ashtabula River and Fields Brook. The boundary values may be constant or time-varying. For the tests described herein, constant inflows of 348 cu m/sec (12,300 cfs) and 14 cu m/sec (500 cfs) were specified for the Ashtabula River and Fields Brook, respectively. The Ashtabula River inflow value was obtained from the August 1979 Flood Insurance Study for the City of Ashtabula, Ohio, and represents the peak discharge for the 100-year flood. The inflow value for Fields Brook was estimated by drainage area ratio. These estimates of peak discharge will be checked and flood hydrographs will be developed during planned hydrologic studies of the basin.[2]

A range of Lake Erie stages at the downstream boundary, shown in the following tabulation, were tested in the model for the peak discharge of the 100-year flood event:

Description	Lake Erie Elevation, m (ft) IGLD 1955
Low-water datum	173.3 (568.6)
Average water level (from NOAA Chart 14836 of 24 Nov 79)	174.3 (571.8)
Extreme high water (from NOAA Chart 14836 of 24 Nov 79)	174.8 (573.5)
2 December 1985, 1900 hours at Erie, PA	175.1 (574.5)

Also, a dynamic simulation of the 1-3 December 1985 storm event was performed by specifying a time-series of stage values observed at the Erie, PA, gauge (Figure 8) coincident with the 100-year flood inflows. Ashtabula is located between the Fairport, OH, and Erie, PA, gauges. In general, lake level fluctuations at the Erie gauge are significantly larger than those observed at the Fairport gauge; therefore, the event simulated in the model probably is more severe than the actual event experienced at Ashtabula. The dynamic (see next page) simulation used a 1-hr time-step. Each set of boundary conditions was tested on both the pre- and postdredging meshes.

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[1] Ven Te Chow. (1959). *Open-channel hydraulics.* McGraw-Hill, New York.

[2] Memorandum for Record, CEWES-HR-M, 22 February 1994, Subject: "Time and Cost Estimate for Data Collection and Analysis and Numerical Model Studies of Sediment Transport in the Ashtabula River System."

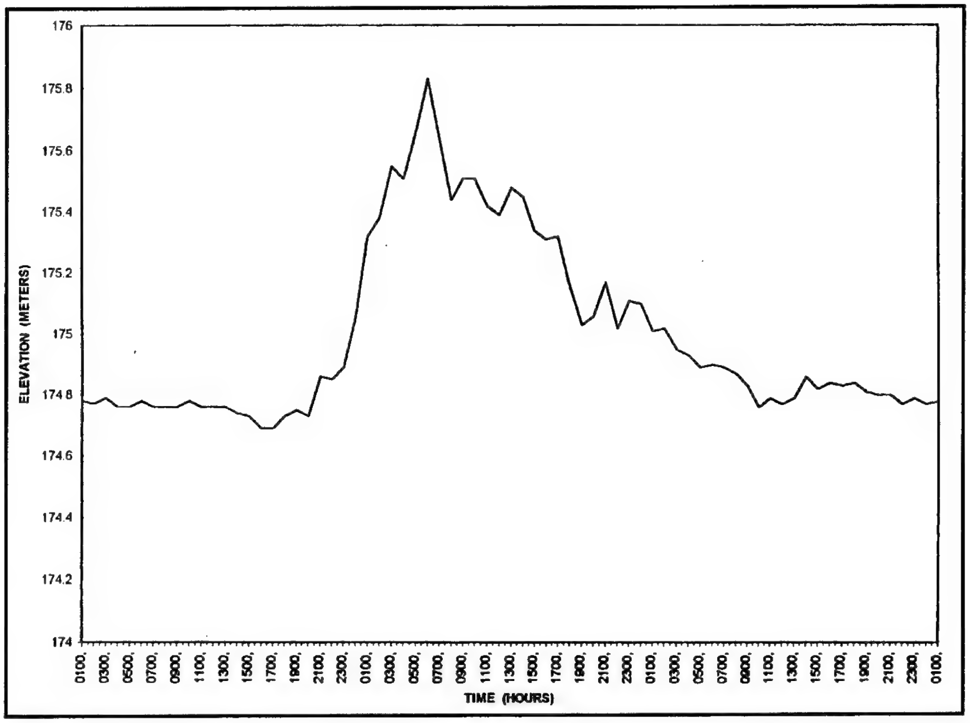

Figure 8. Observed Lake Erie stage at Erie, PA, 1-3 December 1985

Test Results

Model results are presented as a series of contour maps (Plates 1-15) of computed bed shear stress in pascals. The test conditions corresponding to each plate are described in Table 1. The study area was divided into three reaches (Figure 9) for presentation of the contour maps. Reach 1 covers the portion of the waterway from the 5th Street Bridge to river mile 1. Reach 2 covers the portion from river mile 1 to the confluence with Fields Brook. Reach 3 covers the portion from Fields Brook to the upstream limit of the navigation channel (about river mile 2). Results are presented for mesh bathymetry developed from hydrographic surveys performed both before (B93) and after (A93) the 1993 interim dredging for the first set of boundary conditions. Dynamic simulation results are presented for 1900 hours on 2 December 1985, the approximate time of peak flow from the river.

Comparison of model results for pre- and postdredging mesh bathymetry revealed no significant differences in computed bed shear stress as demonstrated by comparing Plates 1-3 (predredging) with Plates 4-6 (postdredging). Planned higher resolution models of the system, as discussed under "Model Development," may detect localized changes in bed sheer stress produced by the 1993 interim dredging. Dredging to greater depths sufficient to significantly increase the cross-sectional area of the channel would be expected to reduce average flow velocities causing a corresponding decrease in bed shear stress.

Table 1
Index to Bed Shear Stress Contour Maps

Plate	Reach	Mesh	Lake Erie Stage m (ft) IGLD 1955
1	1	B93	173.3 (568.6)
2	2	B93	173.3 (568.6)
3	3	B93	173.3 (568.6)
4	1	A93	173.3 (568.6)
5	2	A93	173.3 (568.6)
6	3	A93	173.3 (568.6)
7	1	A93	174.3 (571.8)
8	2	A93	174.3 (571.8)
9	3	A93	174.3 (571.8)
10	1	A93	174.8 (573.5)
11	2	A93	174.8 (573.5)
12	3	A93	174.8 (573.5)
13	1	A93	175.1 (574.5)
14	2	A93	175.1 (574.5)
15	3	A93	175.1 (574.5)

For steady-state simulations, reducing Lake Erie stages at the downstream boundary increased the water surface slope and velocity, producing increased bed shear stress. Thus, simulations using the low-lake level for the downstream stage boundary computed the greatest bed shear stress levels as shown in Plates 4-6. The extreme monthly low water observed at Ashtabula, OH, prior to 1979 was approximately 173.0 m (567.5 ft). As shown in Plates 7-12, higher Lake Erie stages produced lower bed shear stress levels. The computed bed shear stress for the peak discharge of the 100-year flood event exceeded the measured critical shear stress for erosion of the bed material for the entire range of Lake Erie stages in most of the river channel.

For the dynamic simulation, the storage and subsequent release of water from the river in response to varying lake levels produced computed bed shear stress contours (Plates 13-15) similar to the results of the steady-state high- water simulation (Plates 10-12). This comparison implies that the additional flow induced by the falling lake levels increased computed bed shear stress enough to offset the expected decrease in shear stress due to the higher lake level. However, the dynamic effects are small compared to the effect of the peak 100-year flood discharge. It should be noted that while the December 1985 event simulated in the model was severe in terms of lake-driven flooding and

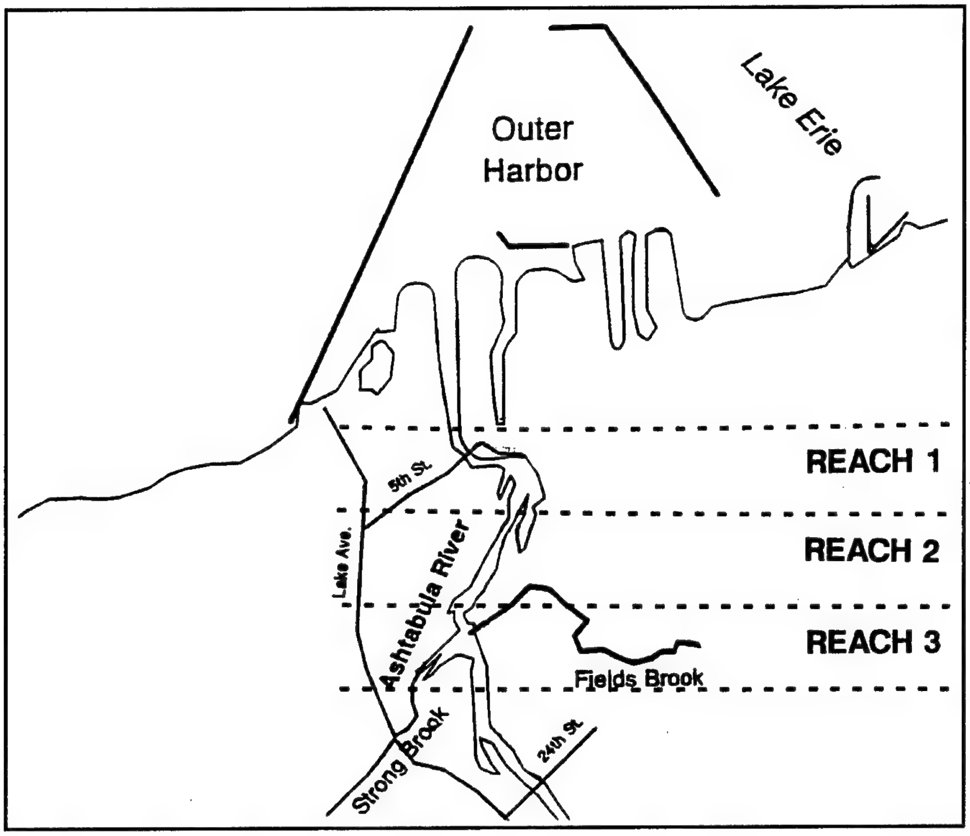

Figure 9. Ashtabula River reach locations

shoreline erosion, it may not be a representative worst-case event for scour of the Ashtabula River channel. It should also be noted that lake-driven currents may influence the distribution of sediment deposition within the Ashtabula River.

4 Conclusions and Recommendations

Based on the preliminary results, the shear stress applied to the bed at the peak of a large flood event will exceed the critical shear stress for erosion of bed material. Therefore, the bed material will scour during some portion of the flood event. The applied shear stress and the resulting scour will be greater for floods coincident with relatively low lake levels. The magnitude of scour will be dependent on a number of unquantified factors, including the shape of the flood hydrograph, the erodibility of subsurface bed material layers, and the sediment yield from the watershed. Dynamic model evaluations of Lake Erie stages should continue at a reduced level of effort to determine if induced currents can produce significant bed shear stress levels.

Laboratory analysis of the surficial bed material indicated that compaction may occur under the weight of subsequent deposits. Thus, subsurface material may be more resistant to erosion. Resolution of this issue will require obtaining deeper sediment samples for analysis.

The field data that have been collected to date are essentially of low flows. It is recommended that the second field data effort be postponed until the spring of 1995. This is usually a period of significant storm events and snowmelt and will allow for extended periods of increased flow in the river and rises in river stage (water levels). This will also provide an opportunity to obtain the equipment for deeper sampling of the riverbed material. Field data collected during the spring of 1995 will not be available prior to the planned completion of model testing. If the results of the second field data effort are significantly different from the first, additional model testing may be required to assimilate the field data into the final analysis of the river system.[1]

The planned hydrologic analysis of the basin, required to determine the shape of the flood hydrograph, should be initiated immediately. The use of a standard hydrologic model, such as HEC-1, is recommended with consideration given to state-of-the-art methods that may be better able to define the volume of the flood hydrograph.

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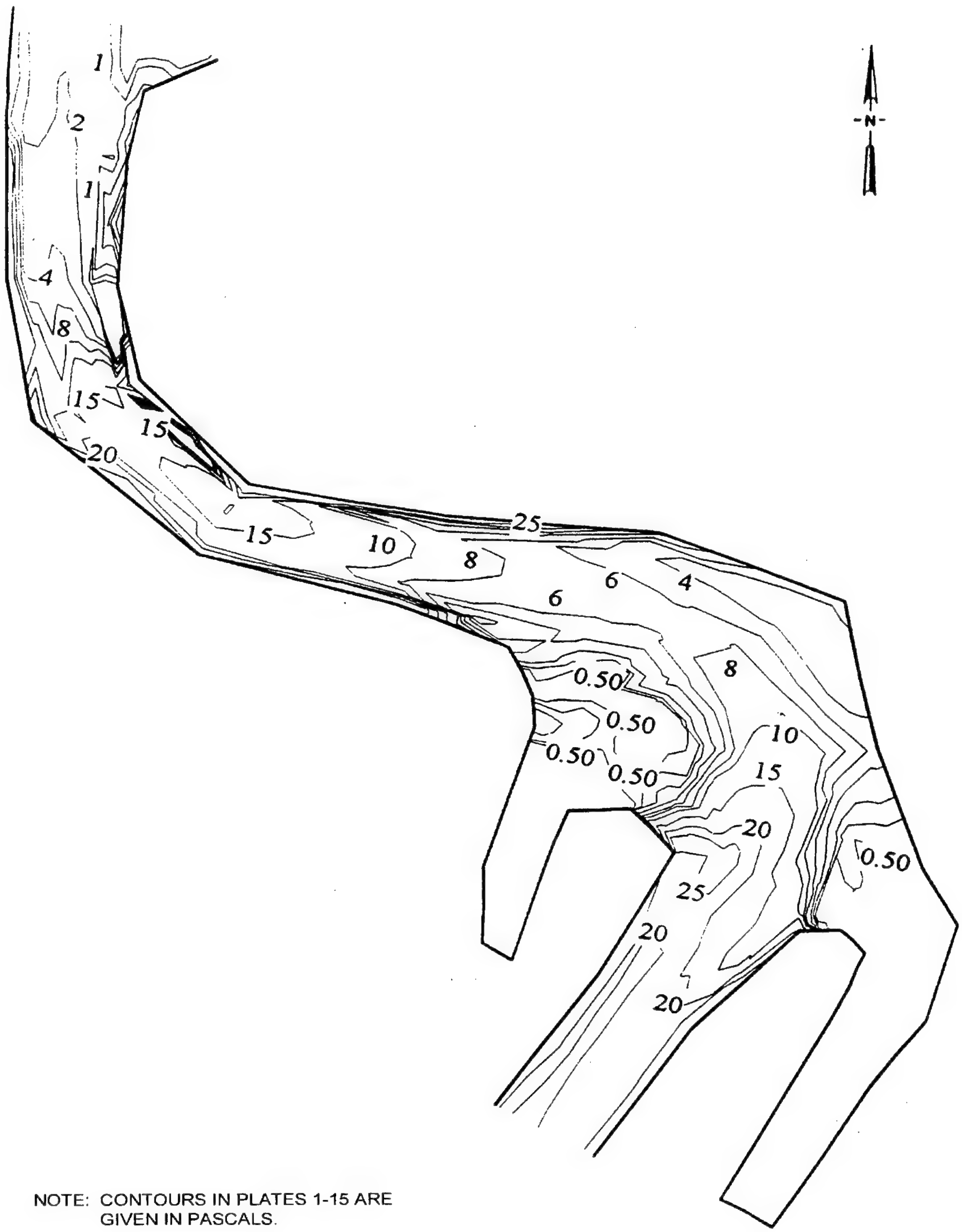
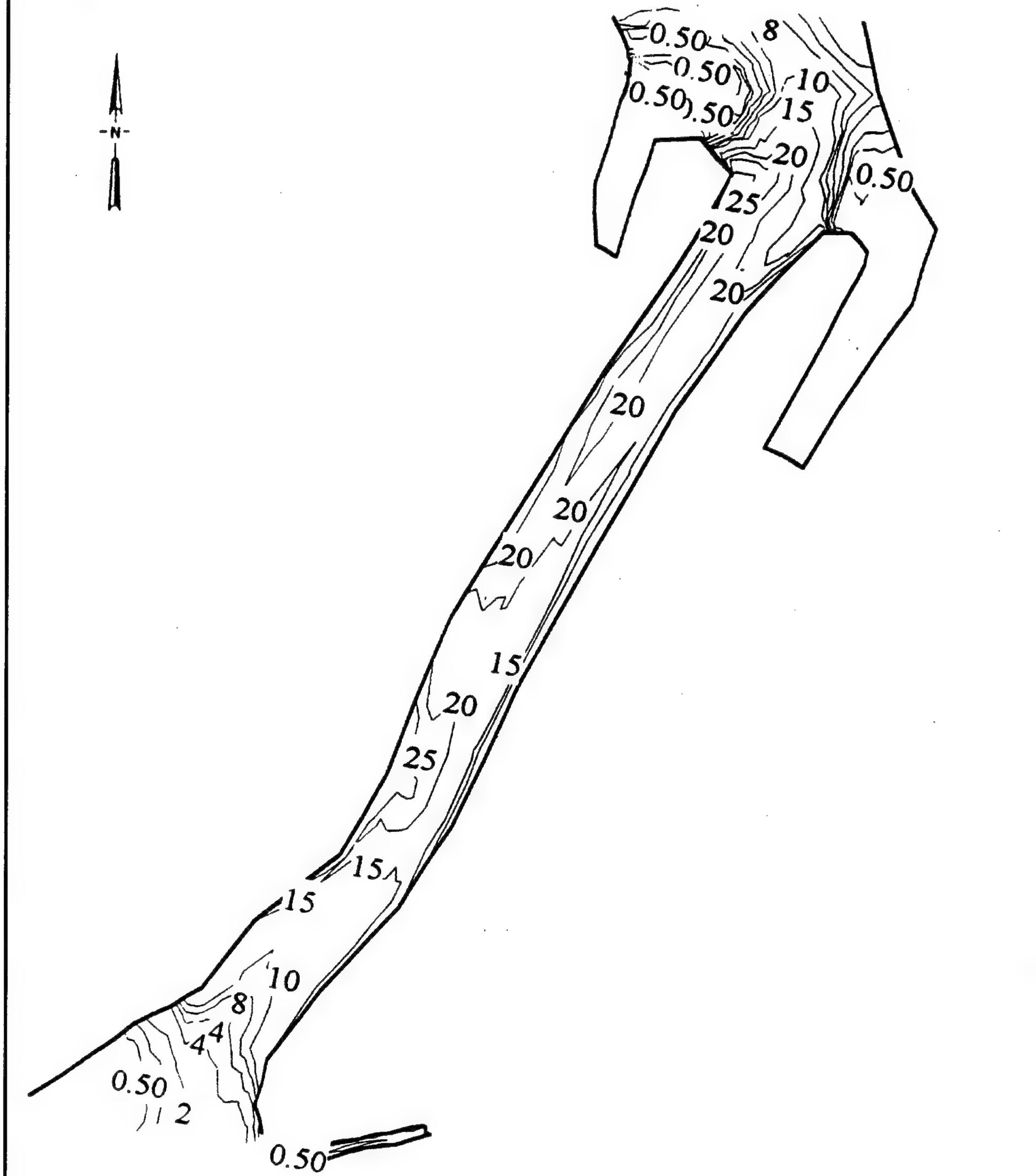
[1] This report is the first in a series of four reports prepared by ERDC documenting this study. These recommendations were made in August of 1994 and were based on the interim study results described in this report. The subsequent resolution of these issues and final study results are described in Reports 2, 3, and 4 of this series.



NOTE: CONTOURS IN PLATES 1-15 ARE GIVEN IN PASCALS.

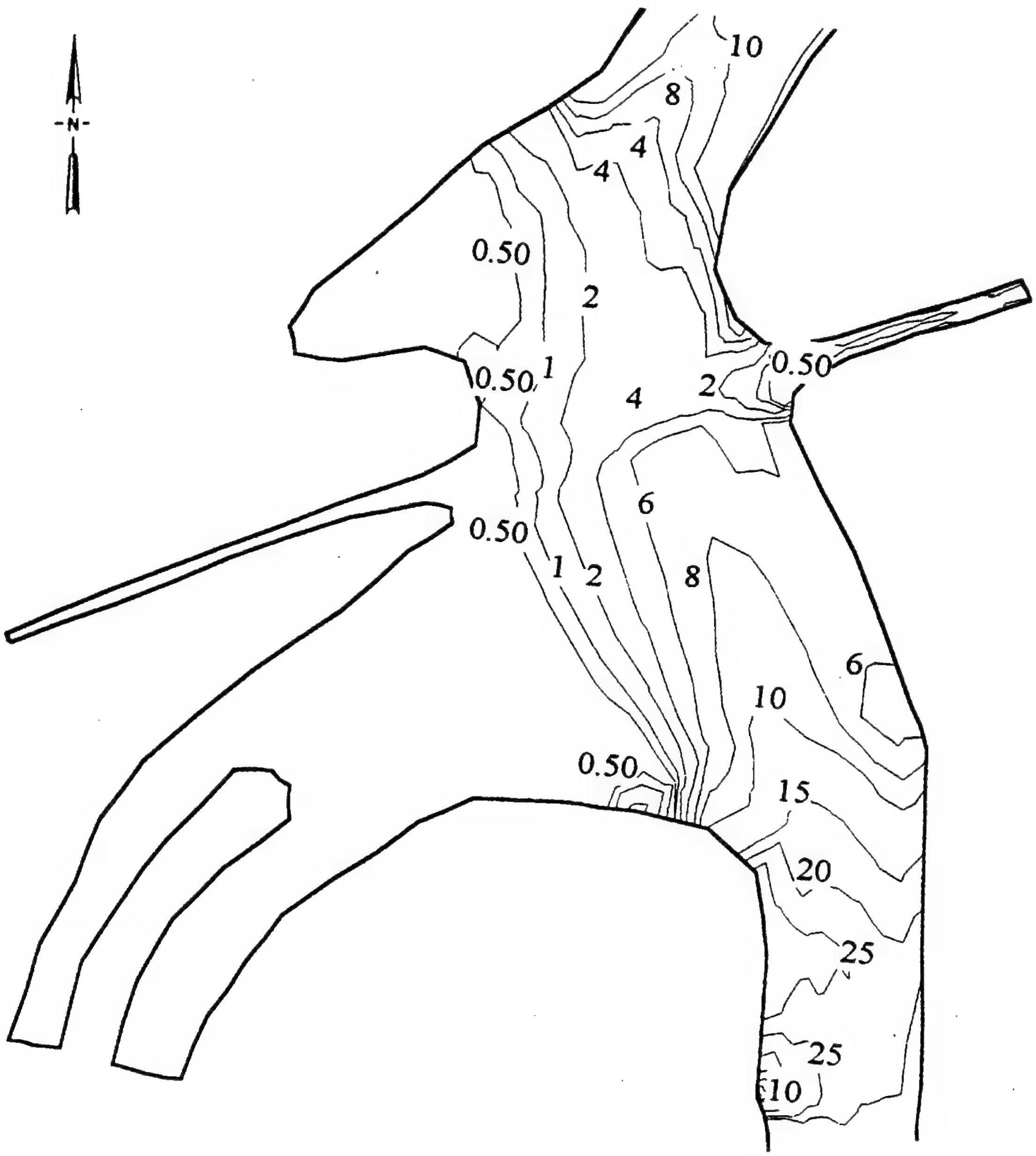
COMPUTED BED SHEAR STRESS CONTOURS
REACH 1, PREDREDGING, LOW-WATER DATUM
100-YEAR FLOOD DISCHARGE

Plate 1

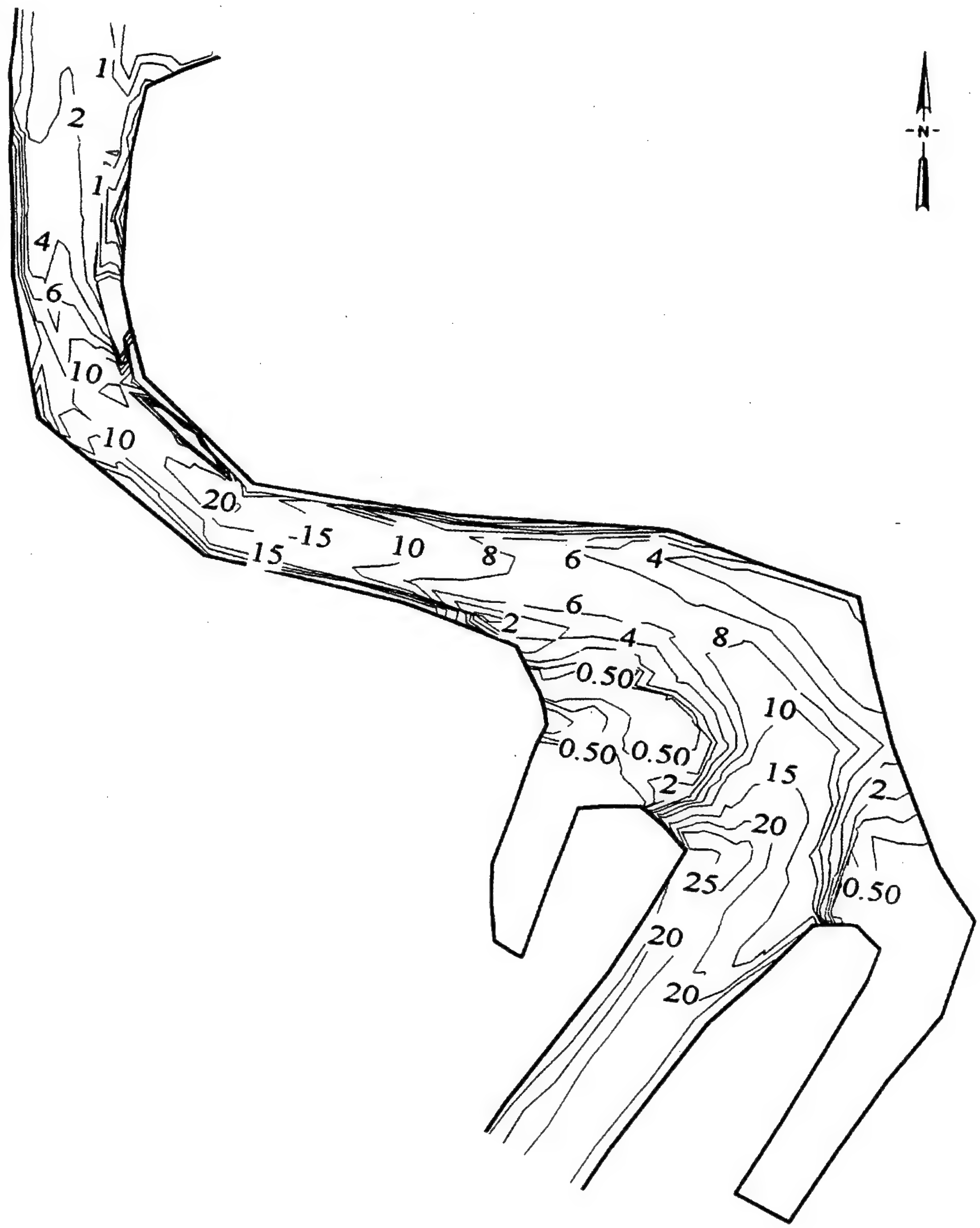


COMPUTED BED SHEAR STRESS CONTOURS
REACH 2, PREDREDGING, LOW-WATER DATUM
100-YEAR FLOOD DISCHARGE

Plate 2

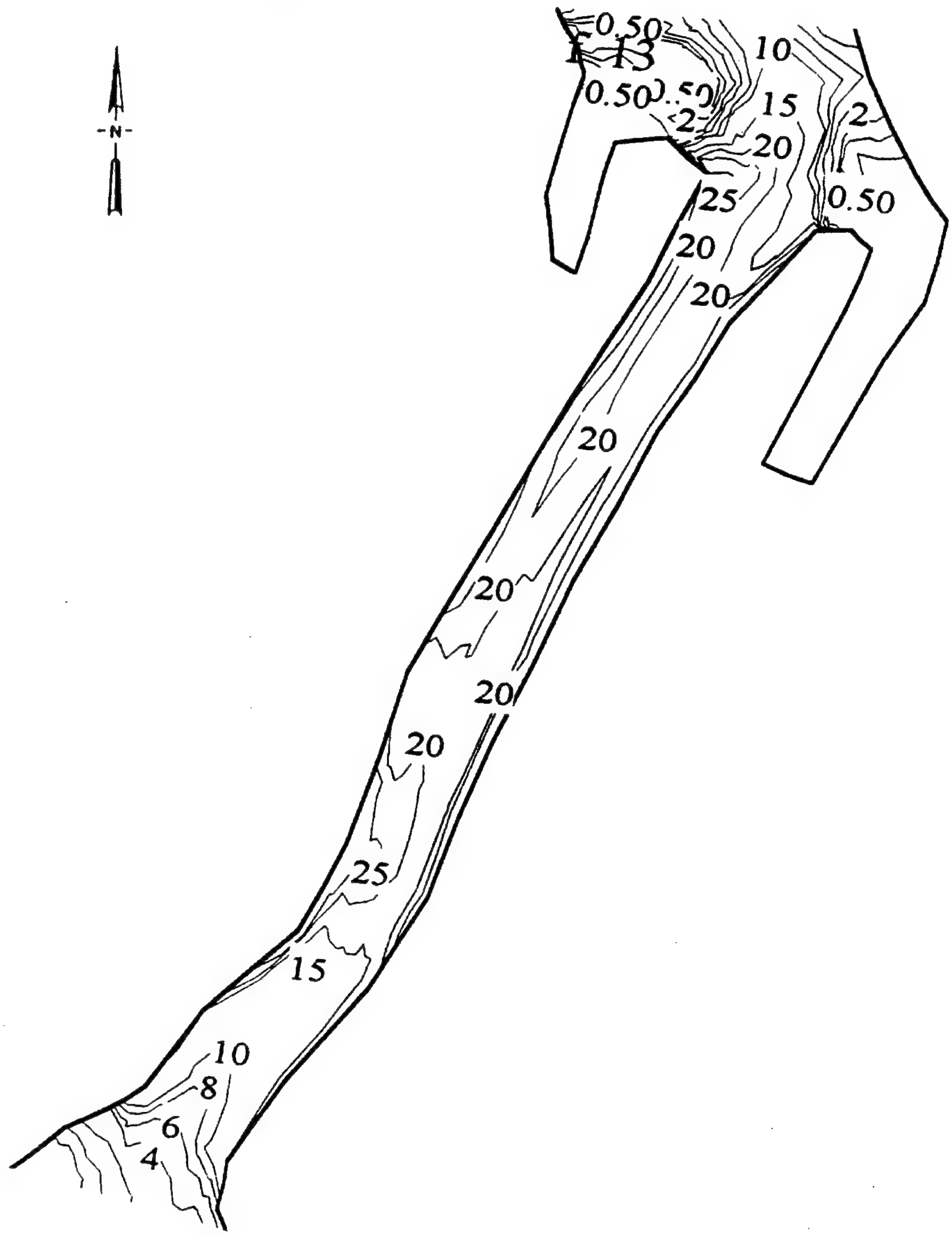


COMPUTED BED SHEAR STRESS CONTOURS
REACH 3, PREDREDGING, LOW-WATER DATUM
100-YEAR FLOOD DISCHARGE

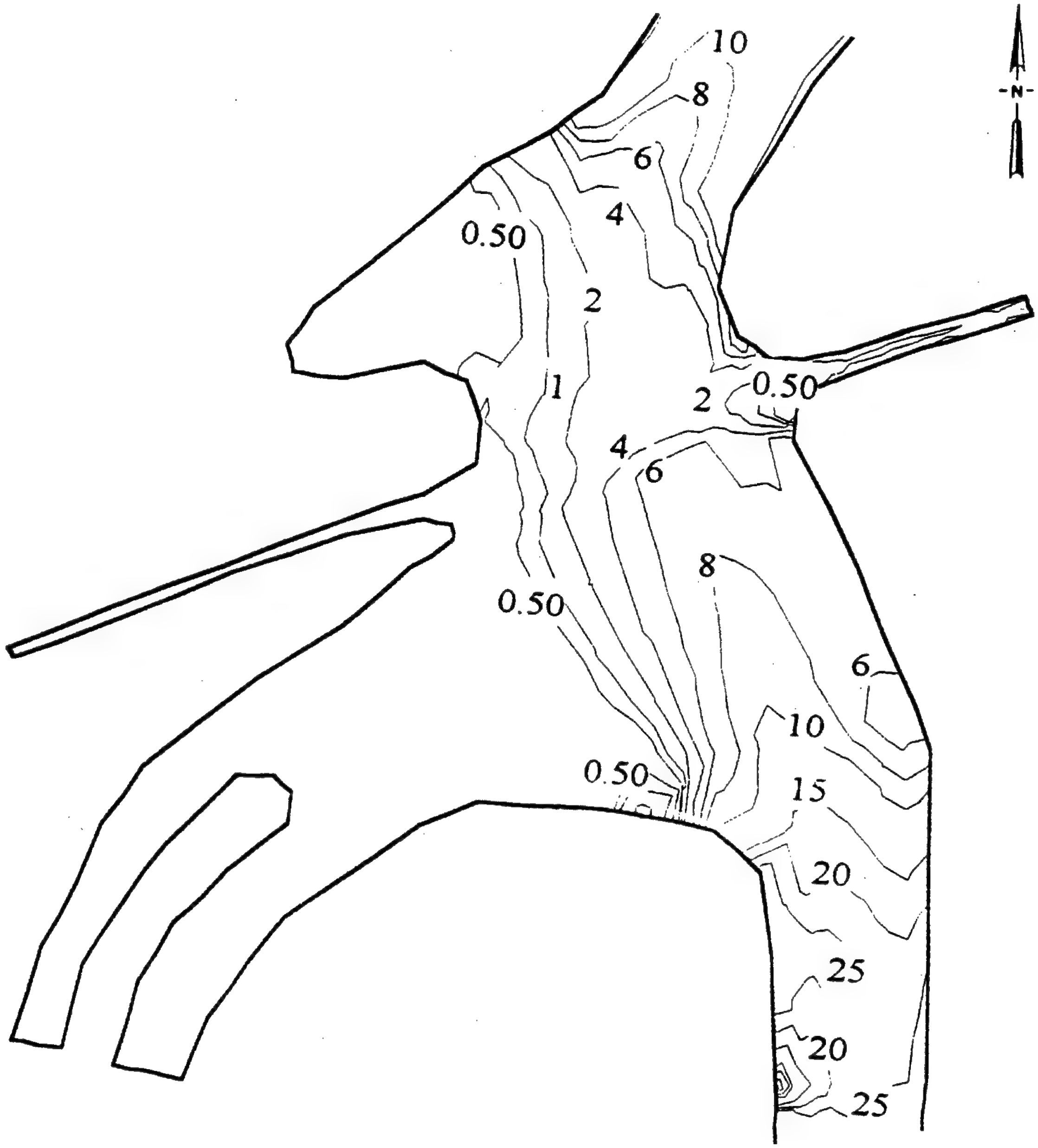


COMPUTED BED SHEAR STRESS CONTOURS
REACH 1, POSTDREDGING, LOW-LAKE LEVEL
100-YEAR FLOOD DISCHARGE

Plate 4

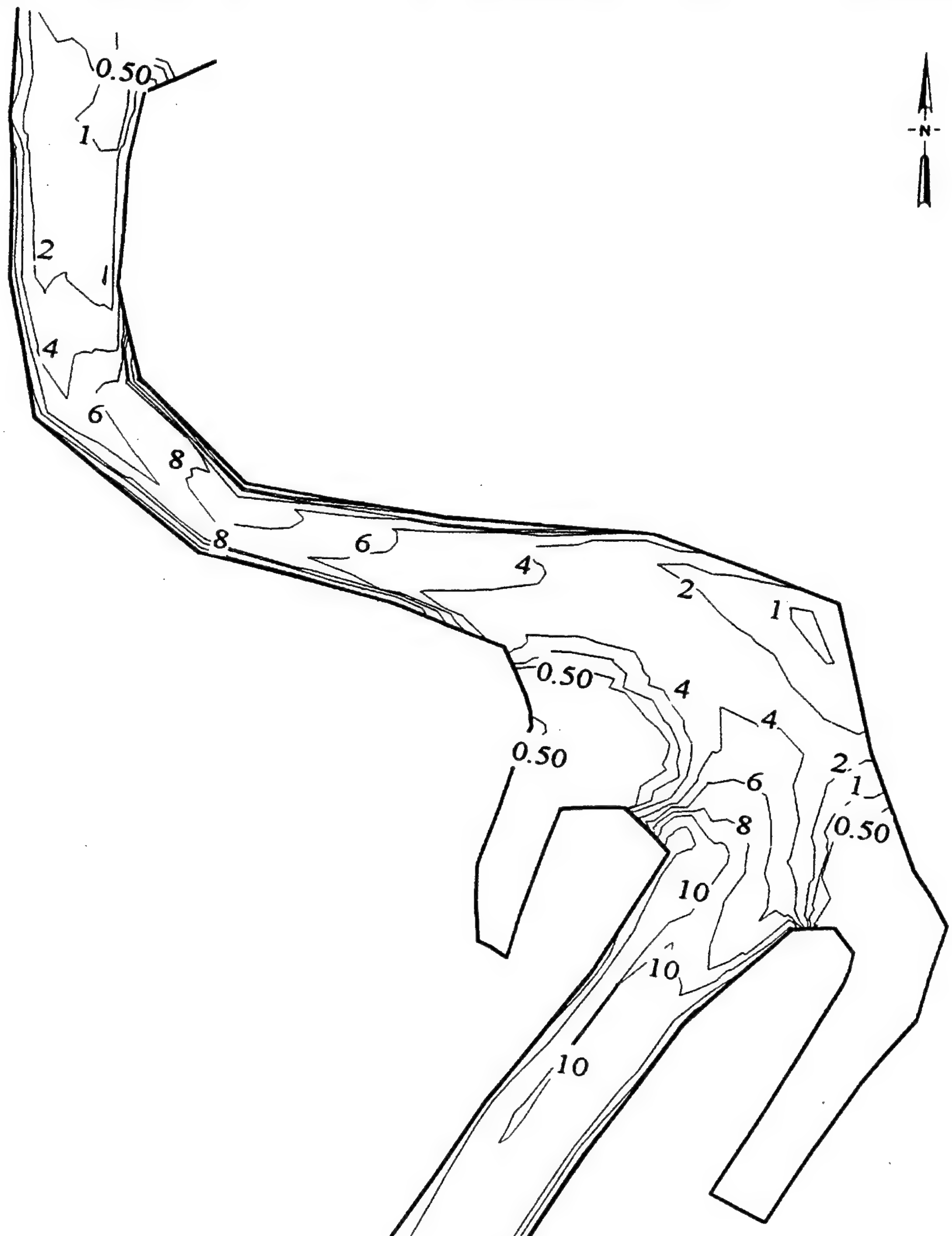


COMPUTED BED SHEAR STRESS CONTOURS
REACH 2, POSTDREDGING, LOW-LAKE LEVEL
100-YEAR FLOOD DISCHARGE



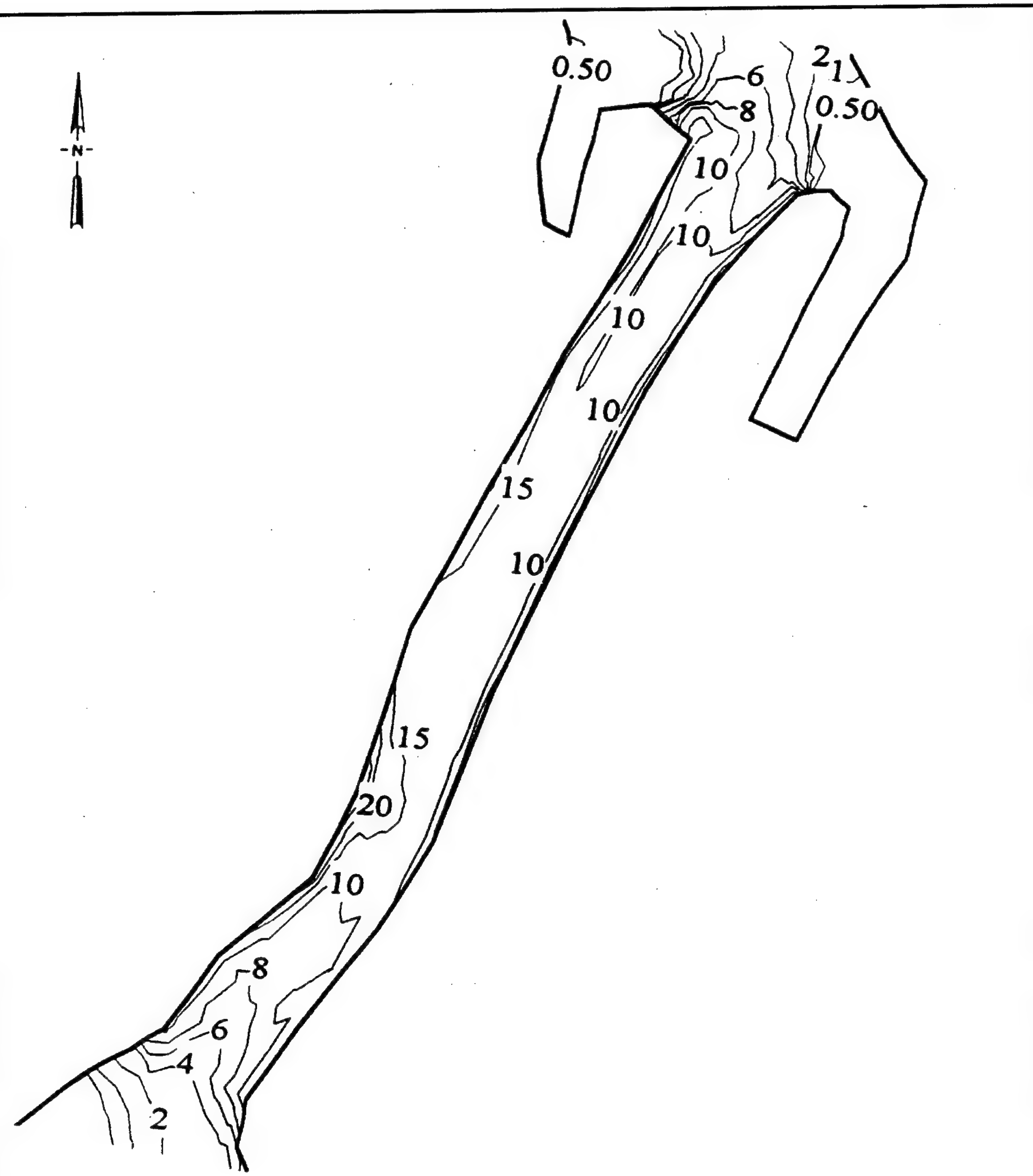
COMPUTED BED SHEAR STRESS CONTOURS
REACH 3, POSTDREDGING, LOW-LAKE LEVEL
100-YEAR FLOOD DISCHARGE

Plate 6



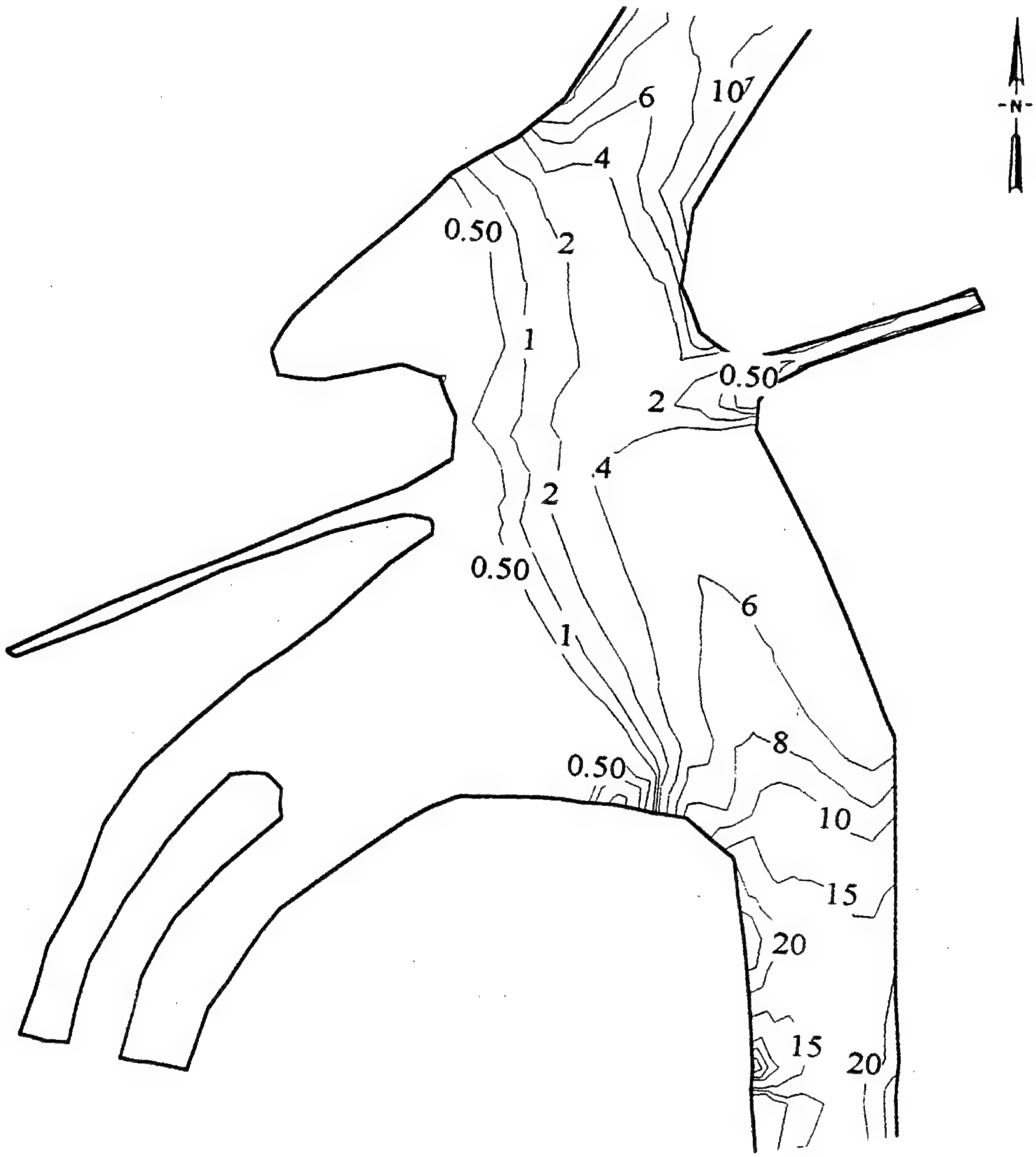
COMPUTED BED SHEAR STRESS CONTOURS
REACH 1, POSTDREDGING, NORMAL LAKE LEVEL
100-YEAR FLOOD DISCHARGE

Plate 7



COMPUTED BED SHEAR STRESS CONTOURS
REACH 2, POSTDREDGING, NORMAL LAKE LEVEL
100-YEAR FLOOD DISCHARGE

Plate 8



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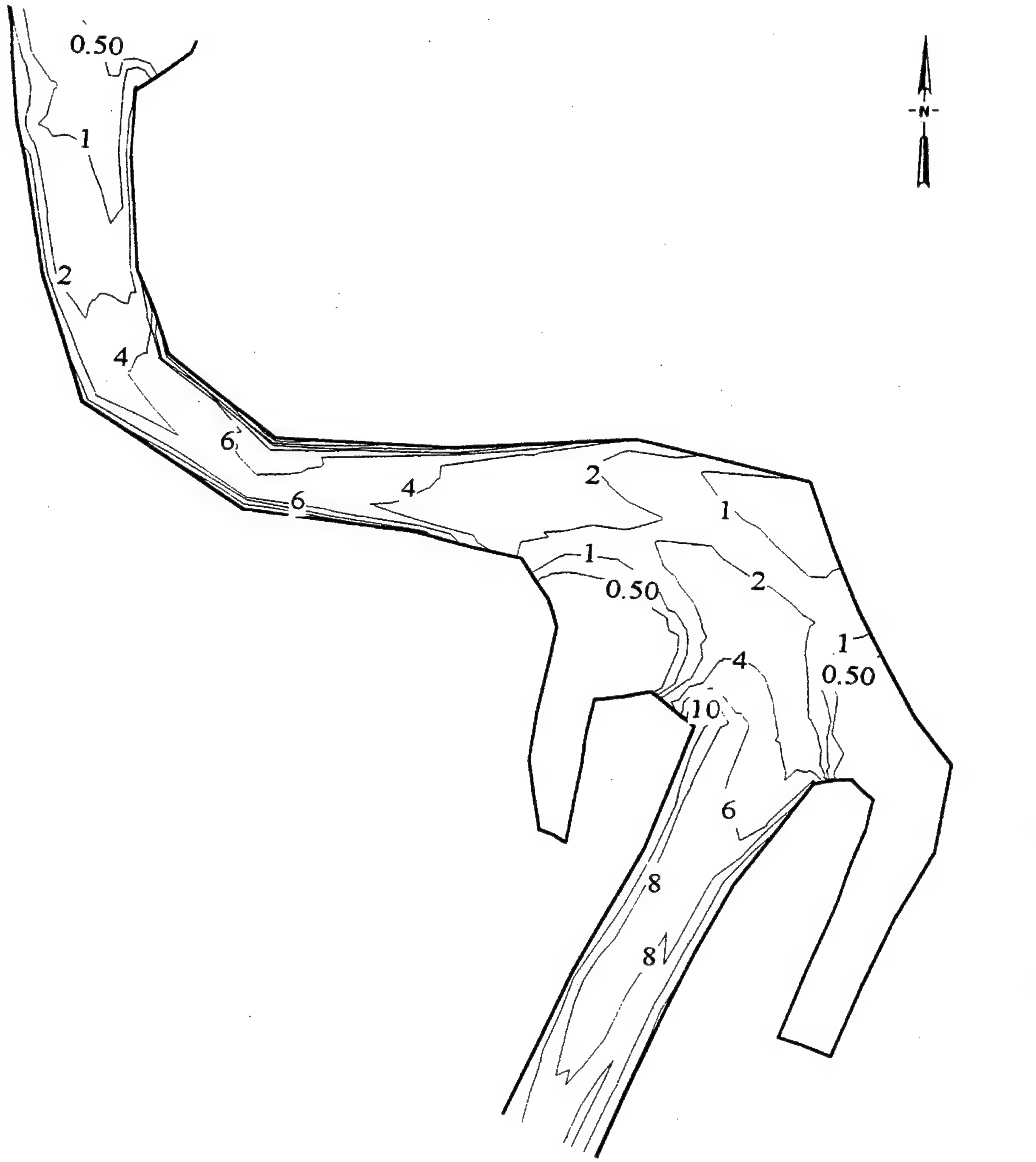
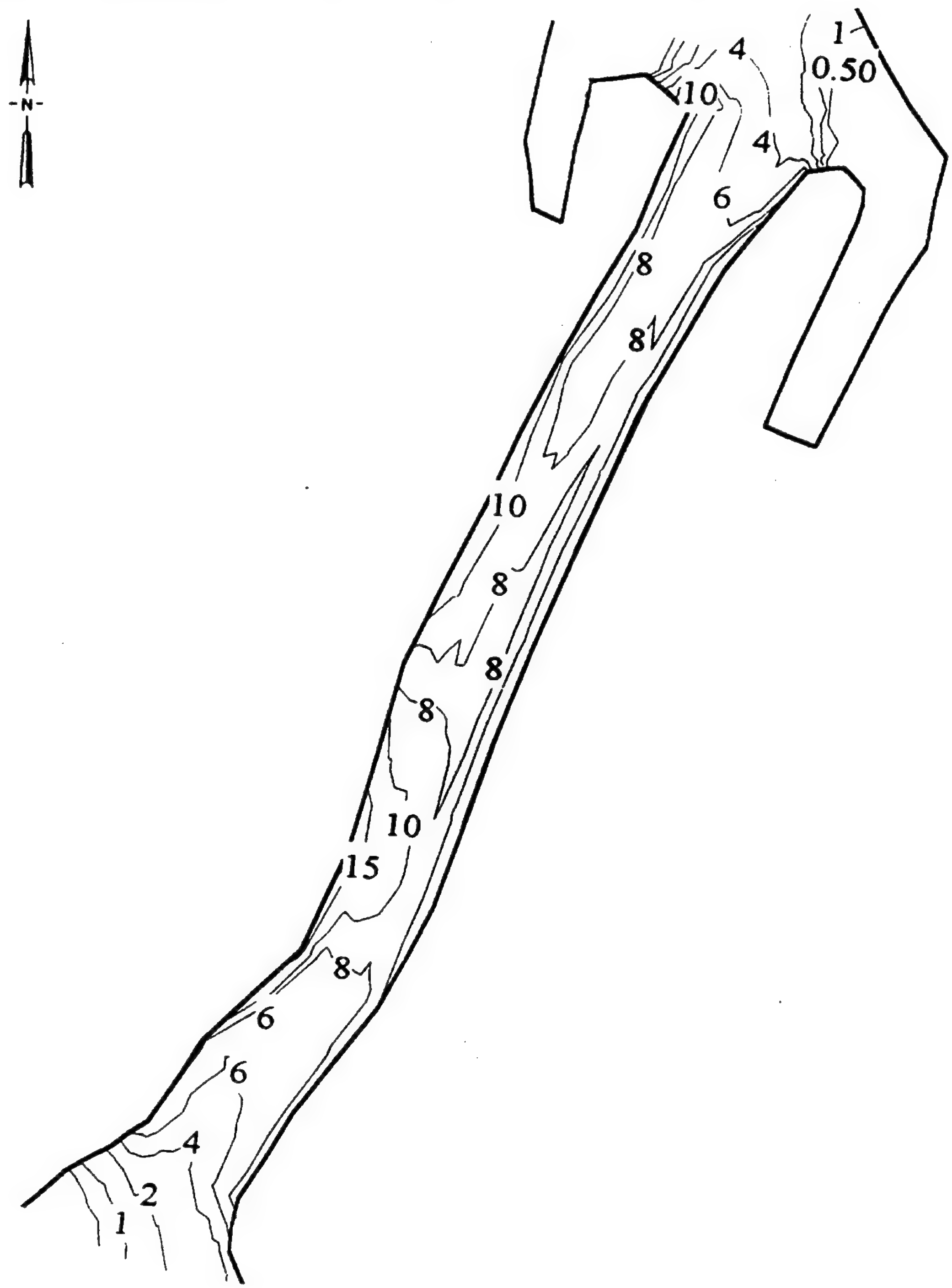
REACH 3, POSTDREDGING, NORMAL LAKE LEVEL
100-YEAR FLOOD DISCHARGE



COMPUTED BED SHEAR STRESS CONTOURS
REACH 1, POSTDREDGING, HIGH-LAKE LEVEL
100-YEAR FLOOD DISCHARGE

Plate 10



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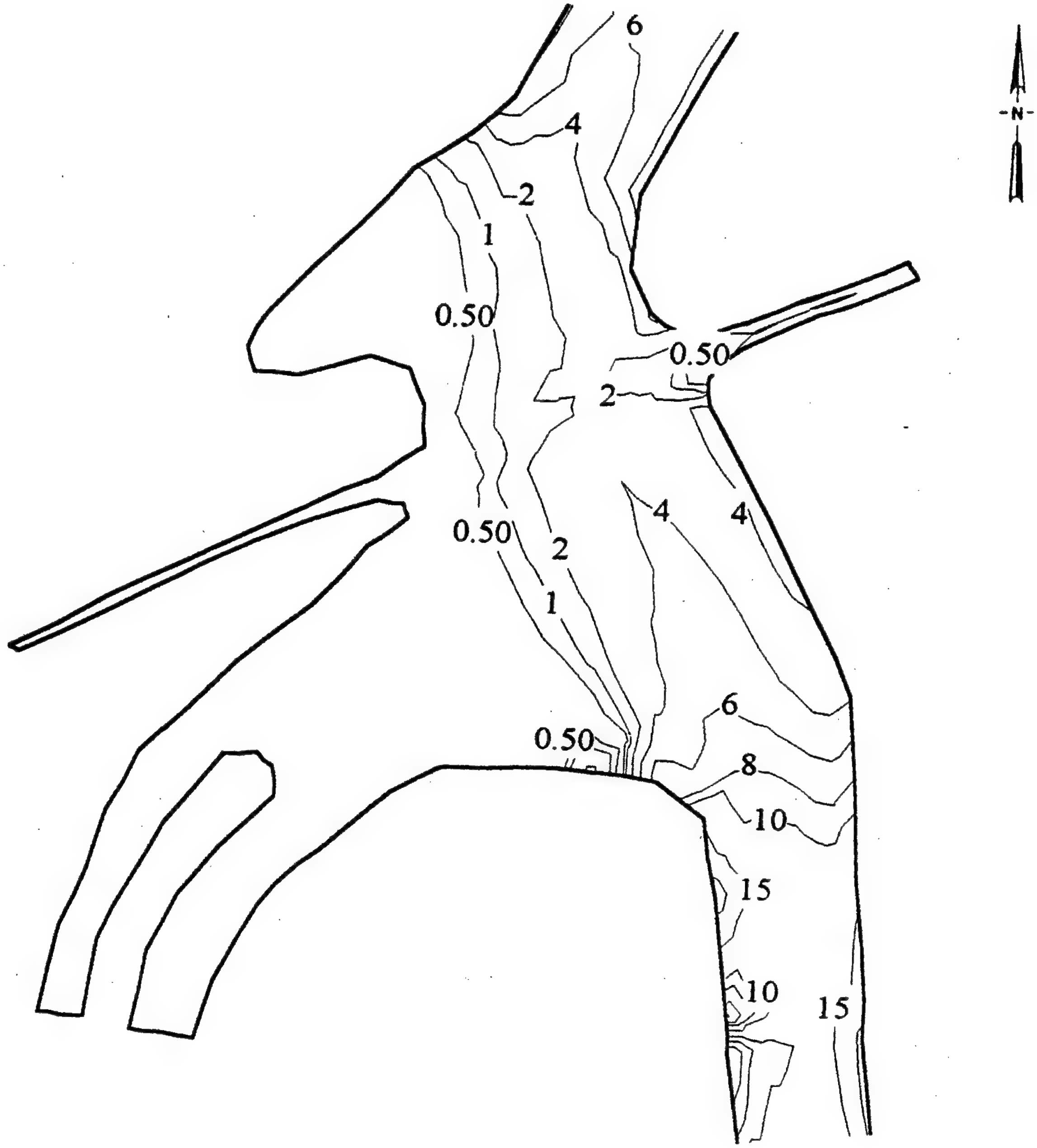
REACH 2, POSTDREDGING, HIGH-LAKE LEVEL
100-YEAR FLOOD DISCHARGE



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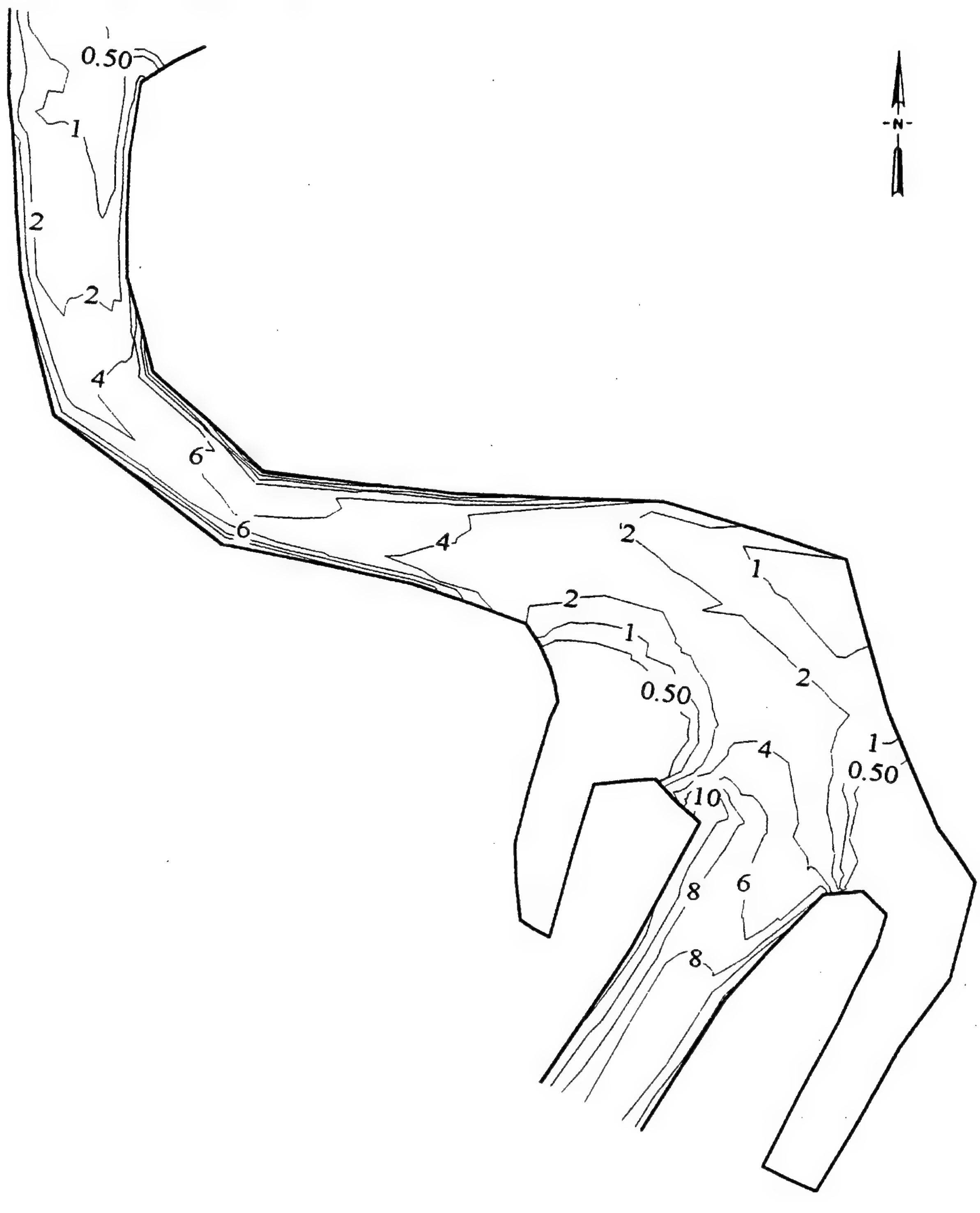
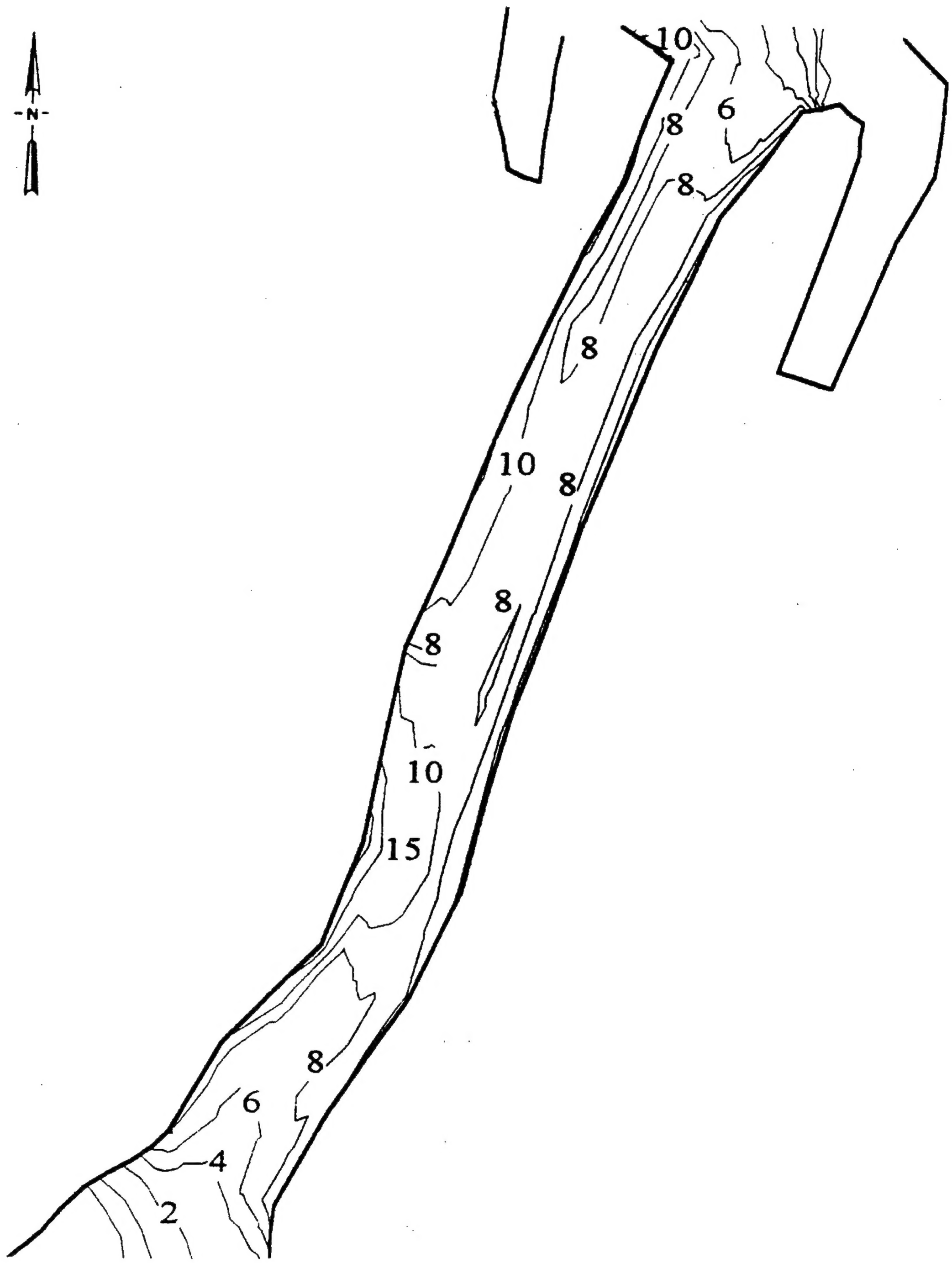
REACH 3, POSTDREDGING, HIGH-LAKE LEVEL
100-YEAR FLOOD DISCHARGE

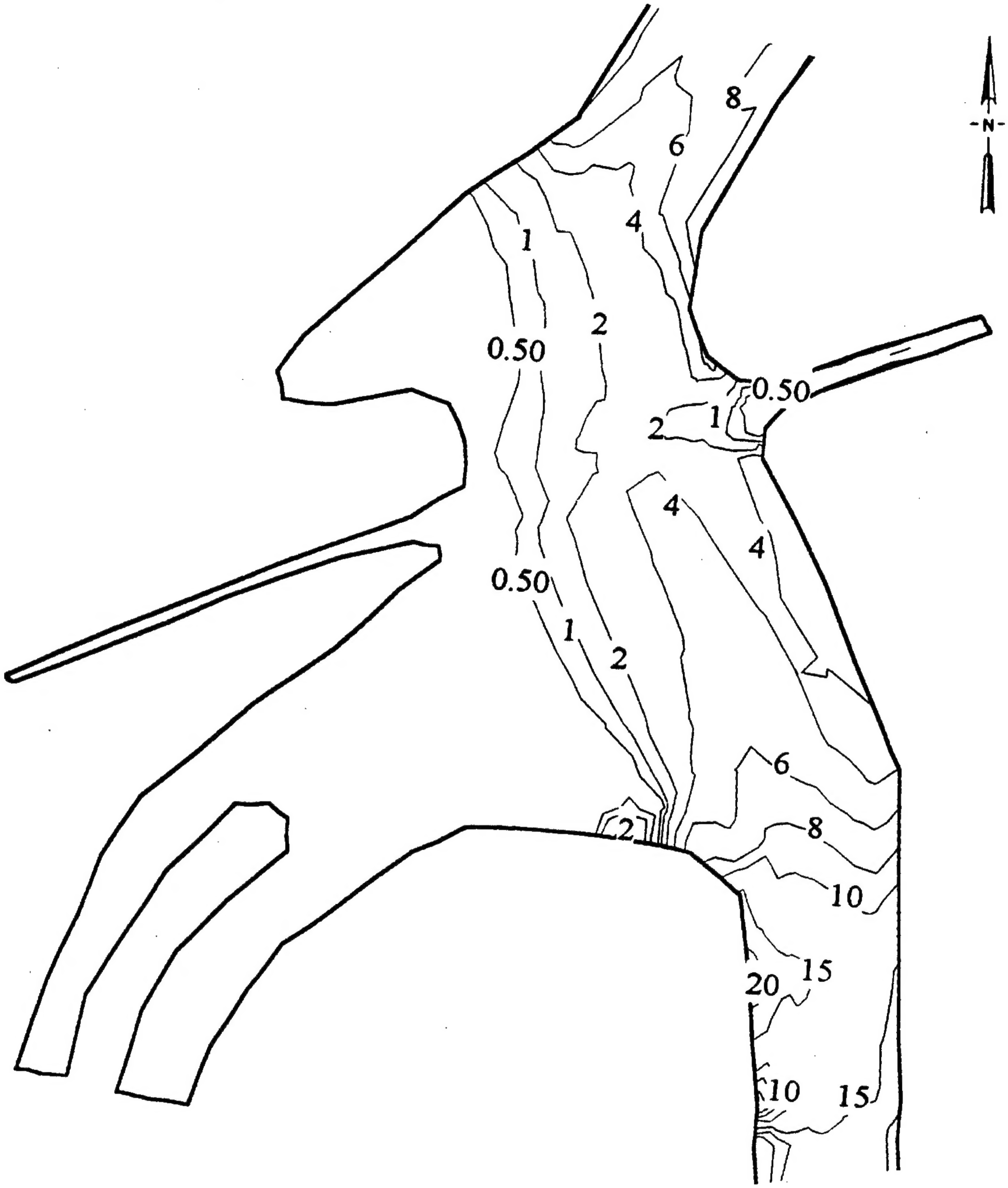


COMPUTED BED SHEAR STRESS CONTOURS
REACH 1, POSTDREDGING
OBSERVED LAKE ERIE STAGE
ERIE, PA
1-3 DECEMBER 1985



COMPUTED BED SHEAR STRESS CONTOURS
REACH 2, POSTDREDGING
OBSERVED LAKE ERIE STAGE
ERIE, PA
1-3 DECEMBER 1985

Plate 14



COMPUTED BED SHEAR STRESS CONTOURS
REACH 3, POSTDREDGING
OBSERVED LAKE ERIE STAGE
ERIE, PA
1-3 DECEMBER 1985

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14. ABSTRACT

A field data collection effort was initiated on 4 June 1994 to monitor water-level fluctuations, suspended sediment concentrations, and bottom material sampling for sediment classification. Water level fluctuations, at 15-min sampling intervals, were obtained at four locations using continuous recording water level sensors. Water samples, obtained during a significant water level rise, were collected using float activated automatic water samplers. Bottom material samples were obtained using two types of sampling devices. A 6-in. box core sampler, for collecting undisturbed samples, and a push core sampler, for collecting samples for subsectioning, were the devices used. River current measurements were performed at four data collection ranges. Acoustic Doppler Current Profile (ADCP) equipment were used to obtain the velocity data. Monthly service trips were scheduled to perform maintenance and data retrieval on the long-term equipment.

Preliminary data analysis of velocity profiles indicated the velocity range was 0 - 30 cm/sec. Laboratory erosion tests indicated the critical shear stress for commencement of surface erosion between 0.2 - 0.6 Pa.

A preliminary TABS-MD finite element modeling system was developed to provide multidimensional solutions to open-channel flow and sediment transport problems. Finite element meshes were developed using National Oceanic and Atmospheric Administration (NOAA) survey chart of the area and recent hydrographic survey data collected by the U.S. Army Engineer District, Detroit. Typical mesh element size was 120 m (400 ft) longitudinally and 18 m (60 ft) laterally.

(Continued)

15. SUBJECT TERMS

Acoustic Doppler Current Profiler	Bed shear stress	Hydrodynamic model
Bed sediments	Field data collection	Lake Erie

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER *(include area code)*
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Comparison of pre- and post-dredging mesh batheymetry revealed no significant differences in computed bed shear stress. However, dredging to greater depths, sufficient to significantly increase the cross-sectional area of the channel would be expected to reduce average flow velocities causing a corresponding decrease in bed shear stress. Natural events such as an unusual reduction in stages in Lake Erie would increase the slope and velocity, producing increased bed shear stress.